Addition of Phosphates, Proteins, and Gums to Reduced-Salt Frankfurter Batters

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ABSTRACT

Reducing the added salt levels in frankfurter batters from 2.5 to 1.5% decreased water binding abilities. Gel strength was less affected and fat release least affected. Tripolyphosphate and pyrophosphate were very effective at levels of 0.1% in restoring the water binding and gel strength. The effectiveness of these phosphates was nearly identical although they have opposing effects on batter pH. Soy isolate and rennet-treated, calcium-reduced dried skim milk improved the batters when added at 1 and 3%. Additions of alginate or especially xanthan gums (0.1–0.3%) improved the water binding but were very detrimental to the gel strength.

INTRODUCTION

SODIUM CHLORIDE REDUCTION in meat products is an important component in the goal of an overall decrease in dietary sodium and the potential lessening of the incidences of high blood pressure and subsequent cardiovascular diseases (Sebranek et al., 1983). A companion paper (Whiting, 1984) shows that reducing the added salt in a frankfurter batter caused an extensive loss of water binding ability. Gel strength was also reduced but fat exudation was not a problem unless salt reductions or processing variable changes were extreme. It is desirable to maintain the functional attributes of meat batters through processing alterations with concomitant sodium reduction.

Phosphates have been added to meat products to improve their binding and water-holding properties. Ellinger (1972), Knipe (1983), and Trout and Schmidt (1983) reviewed the uses of phosphates in meat products and have listed possible modes of action: (1) buffering (raising) the pH, (2) increasing the anionic electrolytes, (3) sequestering cations, (4) raising the ionic strength, and (5) dissociating actomyosin. Phosphates may also crosslink proteins or block reactive sites. Hargett et al. (1980) reported that sodium acid pyrophosphate (SAPP) was the most effective phosphate for improving the firmness and springiness of frankfurters.

Proteins and other extenders have also been used in frankfurters to improve their textural properties (Terrell, 1978). Gums are also capable of binding water and forming gels (Klose and Glicksman, 1972). In this study representatives of these additives were evaluated for their capabilities to affect fat and water exudation and gel strength in frankfurter batters made with a 40% reduction in added salt.

MATERIALS & METHODS

FRANKFURTER BATTERS were made from fresh beef bottom rounds and pork adipose tissues as described previously (Whiting, 1984). Phosphates added in concentrations up to 0.25% were sodium mono- and dibasic phosphate (Pi), sodium acid pyrophosphate (Ventron Inc.), and sodium tripolyphosphate (Stauffer Chemical Corp.). Xanthan gum (Meer Corp.) and sodium alginate (Kimits Corp.) were also tested at 0.1 and 0.3%. Protein extenders used at 1.0 and 3.0% were soy isolate (Supro 620, Ralston Purina Co.), gluten (Supergluten-80, Industrial Grain Prod.), rennet-treated, calcium-reduced, dried skim milk plus calcium lactate (Alatek, Alaco Co.), and collagen prepared as described by Whitmore et al. (1972).

Evaluations of water binding, fat emulsification, and gel strength were performed in duplicate as previously described (Whiting, 1984). The interaction of salt content, pH, and SAPP level was analyzed by factorial design analyses of variance (SAS, 1979).

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RESULTS & DISCUSSION

Phosphate addition

Preliminary trials showed that addition of 0.25% SAPP to the batters reduced their pH from 5.8 to 5.5. Therefore, a factorial experiment was designed with 2.5 and 1.5% salt batters, SAPP, and adjustment of the pH to pH 5.5 or 5.8 with HCl or NaOH independently of SAPP (Table 1). Water exudate was greater at pH 5.5 than 5.8. This was especially significant when 1.5% salt was used. Addition of SAPP greatly reduced the water exudate such that 1.5% salt emulsions with 0.25% SAPP and pH 5.5 were nearly equal to the 2.5% salt batters with no phosphate or pH adjustment. Analysis of variance indicated all three main effects (salt, pH, SAPP) were highly significant ($p < 0.01$); all the two-way interactions were highly significant ($p < 0.01$); and the three-way interaction was significant ($p < 0.05$).

No fat exudate was observed from the 2.5% salt batters without phosphate or pH adjustment and exudate from the 1.5% salt batter was negligible. Lowering pH to 5.5 did not cause any fat exudate with 2.5% salt but resulted in exudate with 1.5% salt which was prevented by addition of 0.12% pyrophosphate. Analysis of variance for fat exudate showed this effect to be highly significant ($p < 0.01$).

Gel strength data were less consistent. Reducing salt concentrations decreased the penetration forces, except for an anomalous value in the batter with 1.5% salt, pH 5.5, and 0.25% SAPP. Lowering of pH generally reduced the gel's strength, and adding pyrophosphate increased the penetration force. Analysis of variance indicated only salt level ($p < 0.05$) and SAPP level ($p < 0.01$) as significant. Hargett et al. (1980) found that SAPP improved texture of frankfurters only slightly, but did not improve moisture retention or cook yields. These frankfurters, however, contained 3.0% added salt. SAPP, therefore, appears to be more effective when the batter is of marginal stability.

Table 1—Water exudate, fat exudate, and gel strength of batters made with sodium acid pyrophosphate and controlled pH

	SAPP (%)	1.5% Salt pH 5.5	1.5% Salt pH 5.8	2.5% Salt pH 5.5	2.5% Salt pH 5.8
Water exudate (mL/30g)	0.0	6.8	2.0	1.7	0.7
	0.12	1.9	0.4	0.2	0.0
	0.25	1.0	0.4	0.1	0.0
Fat exudate (mL/30g)	0.0	1.1	0.1	0.0	0.0
	0.12	0.0	0.0	0.0	0.0
	0.25	0.0	0.0	0.0	0.0
Gel strength (g)	0.0	390	612	665	640
	0.12	565	700	788	835
	0.25	995	768	845	872

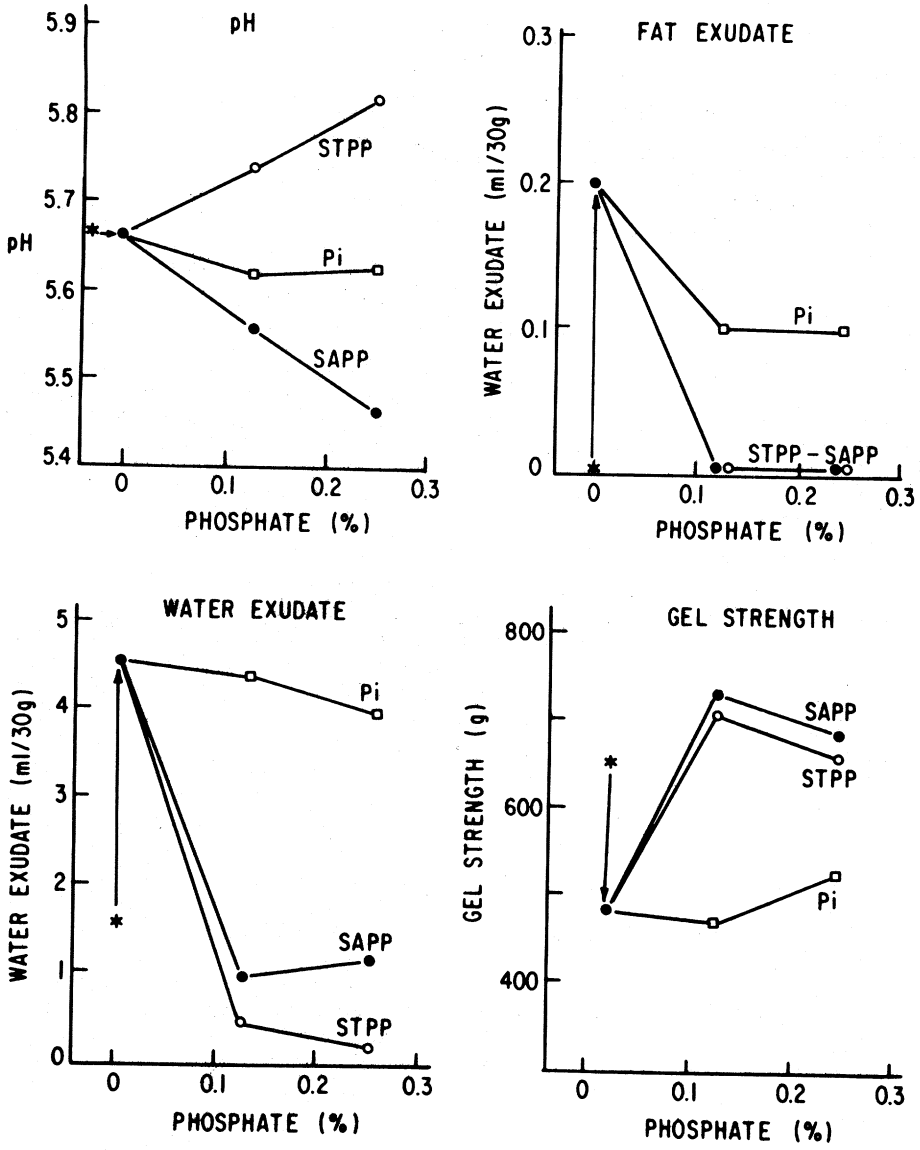

Fig. 1—pH values, water exudates, fat exudates, and gel strengths of reduced-salt batters with added phosphates. The 2.5% salt control is marked with an asterisk and the arrow indicates the change in the 1.5% control. Phosphate containing batters all had 1.5% salt. Values are means of two batters measured in duplicate. Orthophosphate (Pi), □; sodium acid pyrophosphate (SAPP), ●; sodium tripolyphosphate (STPP), ○.

Shults et al. (1972) demonstrated differing abilities of various phosphates to reduce shrink and increase water retention in intact beef. These investigators reported tripolyphosphate to be better than pyrophosphate and much better than orthophosphate. Fig. 1 shows the effect of phosphate type in improving the batter's properties when the salt was reduced. The arrow shows the change from 2.5% salt (*) to 1.5% salt with no added phosphate. The phosphates were added to batters containing 1.5% salt. The pH values were not controlled in this experiment; 0.25% SAPP reduced the pH from 5.66 to 5.46, 0.25% sodium tripolyphosphate (STPP) increased the pH to 5.82, while the sodium mono- and dibasic orthophosphates (Pi) were combined to have no effect on pH.

Water exudate increased from 1.6 to 4.3 ml when the salt level was reduced. Addition of STPP or SAPP to the 1.5% salt batters reduced the water exudate to values less than the 2.5% salt batters. Orthophosphate had no effect. The results generally confirm those of Shults et al. (1972). No fat exudate appeared when STPP or SAPP were added and exudation was reduced with Pi. Gel strength was completely restored with 0.12% STPP or SAPP, but was unaffected by Pi.

The average chopping times decreased with addition of 0.25% SAPP from 91 sec to 85.5 sec indicating an increase of the batters' viscosity. Addition of STPP had a lesser effect. However, Hargett et al. (1980) observed a lowered viscosity in emulsions with added SAPP.

Addition of binders

To determine whether other binders would potentially improve the properties of the meat batter, especially water binding, xanthan and alginate gums were added at 0.1 and 0.3% (Klose and Glicksman, 1972). Protein extenders used at 1.0 and 3.0% were soy isolate; gluten; rennet-treated, calcium-reduced, dried skim milk plus calcium lactate; and collagen. For comparison, batters were also made with 0.05% and 0.10% SAPP. All additives were included at the beginning of the chop as dry powders and replaced an equal weight of lean beef in the formulation. All batters except for the 2.5% salt controls had 1.5% salt.

Data (Fig. 2) from several experimental series were calculated as percentages of their respective 2.5% salt batters. Total exudate is shown since only small amounts of fat were released by a few formulations. The two gums reduced the water exudate to levels below the 1.5% salt controls, xanthan reduced water exudate below the 2.5% controls. However, the gel strength of these gels was very poor, especially with xanthan gum, agreeing with previous data on frankfurters containing xanthan gum (Fox et al., 1983). Soy isolate and rennet-treated, calcium-reduced,

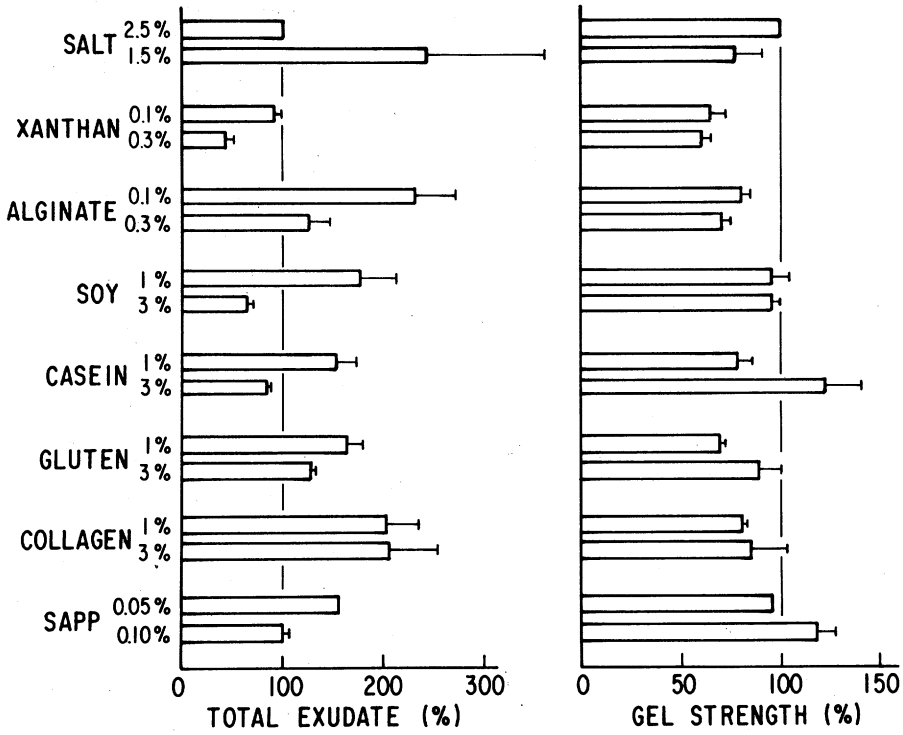

Fig. 2—Total exudates and gel strengths of batters with added gums, proteins, or pyrophosphate. Except for the 2.5% salt control, all batters have 1.5% salt. Values were calculated as a percentage of their respective 2.5% salt controls. Standard deviations are indicated except for the 0.05% SAPP which was a single batter.

dried skim milk were both capable of reducing water extract and restoring gel strength. Gluten was less successful and collagen was poor at improving properties of low salt batters. As shown above, SAPP was effective even when added in amounts as low as 0.05%.

In previous studies, extenders generally have been found to be inferior to myosin for functionality in meat products (Smith et al., 1973; Lauck, 1975; Siegel et al., 1979; Rao et al., 1981; Fox et al., 1983). However, these extenders were generally added to good meat batters where the salt-soluble proteins provided ample water binding and gel strength. This work suggested that in less optimal systems, such as with reduced salt, beneficial effects may result from addition of one or combinations of these extenders. Addition of phosphate was very promising although further work is necessary to determine the mechanisms involved and the best form of phosphate to add. This brief survey of protein extenders also showed several had advantageous properties, additional study would undoubtedly find others and could also examine the sensory consequences of using extenders in reduced salt meat products.

REFERENCES

Ellinger, R.H. 1972. Phosphates in food processing. "CRC Handbook of Food Additives," 2nd ed., Vol. 1, p. 617.
Fox, J.B. Jr., Ackerman, S.A., and Jenkins, R.K. 1983. Effect of anionic gums on the texture of pickled frankfurters. J. Food Sci. 48: 1031.
Hargett, S.M., Blumer, T.N., Hamann, D.D., Keeton, J.T., and Monroe, R.J. 1980. Effect of sodium acid pyrophosphate on sensory, chemical, and physical properties of frankfurters. J. Food Sci. 45: 905.
Klose, R.E. and Glicksman, M. 1972. Gums. "CRC Handbook of Food Additives," 2nd ed., Vol. 1, p. 295.
Knipe, C.L. 1982. Effects of inorganic polyphosphates on reduced sodium and conventional meat emulsion characteristics. Ph.D. thesis, Iowa State Univ., Ames, IA.
Lauck, R.M. 1975. The functionality of binders in meat emulsions. J. Food Sci. 40: 736.
Rao, B.R., Schalk, D., Gielissen, R., and Henrickson, R.L. 1981. Bovine hide collagen as a protein extender in bologna. Oklahoma Agri. Exp. Station, Anim. Sci. Res. Rept. p. 254.
SAS. 1979. Statistical Analysis System Institute, Box 10066, Raleigh, NC 27605.
Sebranek, J.G., Olson, D.G., Whiting, R.C., Benedict, R.C., Rust, R.E., Kraft, A.A., and Woychik, J.H. 1983. Physiological role of dietary sodium in human health and implications of sodium reduction in muscle foods. Food Technol. 37(7): 51.
Shults, G.W., Russell, D.R., and Wierbicki, E. 1972. Effect of condensed phosphates on pH, swelling and water-holding capacity of beef. J. Food Sci. 37: 860.
Siegel, D.G., Church, K.E., and Schmidt, G.R. 1979. Gel structure of nonmeat proteins as related to their ability to bind meat pieces. J. Food Sci. 44: 1276.
Smith, G.C., Juhn, H., Carpenter, Z.L., Mattil, K.F., and Cater, C.M. 1973. Efficacy of protein additives as emulsion stabilizers in frankfurters. J. Food Sci. 38: 849.
Terrell, R.N. 1978. Non-meat additives for sausages and processed meats. Proc. Meat Ind. Res. Conf. p. 17.
Trout, G.R. and Schmidt, G.R. 1983. Utilization of phosphates in meat products. Meat Proc. 22(9): 48.
Whiting, R.C. 1984. Stability and gel strength of frankfurter batters made with reduced NaCl. J. Food Sci.
Whitmore, R., Jones, H., Windus, W., and Naghski, J. 1972. Preparation and visco-elastic properties of fibrous collagen dispersions from limed cattlehide splits. J. Food Sci. 37: 302.
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